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A STUDY OF INSECT POPULATIONS ON CELERY IN THE SANFORD, FLORIDA, DISTRICT

By

C. B. WISECUP, Assistant Entomologist
Truck Crop and Garden Insect Investigations
And
R. L. MILLER, Associate Entomologist
Fruit and Shade Tree Insect Investigations,
Bureau of Entomology,
United States Department of Agriculture.

The major attention of entomologists concerned with celery pests has been directed toward those insects which cause appreciable damage, such as the celery leaf tier, aphids, cutworms, loopers, etc. No systematic survey to determine the general abundance of insects on Florida celery had been made until January 1929, when the junior author, while connected with the Florida State Plant Board, began such studies on the spring, or so-called "late", crop of celery. It was thought that such a survey would show what insects were potential celery pests and might yield information useful for predicting outbreaks. In addition, such information would give a better idea of the importance of natural control and show the seasonal distribution of the insects. In the fall of 1929, when the junior author was transferred to the Mediterranean fruit fly investigations, the studies were taken up by the senior author, beginning soon after celery became established in the field and continuing until the end of the crop season.

Celery *(Apium graveolens)* is a winter crop in Florida. It is grown most extensively on the sandy soil of the St. Johns River valley near Sanford in an area 10 miles long by 3 miles wide. This limited area comprises about 3,500 acres of cultivated land which bears a crop of celery some time between September and the following May each year. The seed beds are started in late

July and August and the first plants are set in the field about September 1. Later plantings follow regularly until some time in January. Harvesting reaches its peak in February and March and declines rapidly through May.

METHOD

Five 1-acre plots were selected on representative farms, the celery on each plot being in a different stage of growth. Starting on January 20, 1929, a collection on each plot was made every Monday and Thursday until all the celery on that plot was harvested.

For the second season, 1929-30, similar collections on three plots were initiated on October 14, and other plots were included in the collections as those on the original plots were discontinued owing to their crops having been harvested. In all, eight plots were included in that season's work.

As a rule two men made the collections, starting as soon as the dew had dried from the celery. Each man made 100 sweeps with a 12-inch net on each plot, crossing two rows of celery at each sweep and zigzagging across the field.

All of the collected insects were shaken to the small end of the net and emptied into labelled 1-quart killing jars. The nets were carefully examined and counts made of all adhering insects. At the close of the day's collecting the contents of the various jars were carefully counted and tabulated. The insects were first classified as to orders and then those orders in which the more important economic forms are found were further subdivided. Thus, in the tables the celery leaf tier and garden flea hopper are treated equally with the orders Diptera and Thysanoptera. Red spiders, though not insects, were recorded because of their economic interest. Common field spiders were recorded because of their predaceous habits.

COMPARISON OF CLIMATIC CONDITIONS FOR THE TWO SEASONS

The temperature for the first season was very near normal until January, when the average mean temperature rose about three degrees above normal and remained so until May (fig. 1). The average mean temperature for this entire celery season was 68.9°F., while the normal average is 65.5°F. (table I, A). The rainfall was much below normal for each month except May, the total precipitation being only 8.44 inches, which is 12.17 inches less than the normal of 20.61 inches. In contrast to this

season, the following season was almost normal. The extremes of temperature compensated for each other so that the departure from the normal was only +1.5°. Figure 1 shows the wide fluctuations in mean temperature from month to month during this season. Rainfall for this period totalled 6.04 inches more than the normal, most of which fell in November and March. Table I, B shows a comparison of the spring, or late-crop, season of the two years. It will be noted that the precipitation for 1929 was 4.94 inches less than normal and the temperature was 5°F. higher than normal, whereas the 1930 spring had 6.51 inches more rainfall than normal and a mean temperature of only 1.4°F. above normal. These differences in precipitation and temperature were found to have a direct bearing on the insect population of the celery fields for the two seasons. In addition to showing the variations from normal of the temperature and precipitation for the crop seasons, figure 1 shows the duration of the survey for each of the two years and, from the relative heights of the two cross-hatched areas, gives an idea of the number of collections made each season.

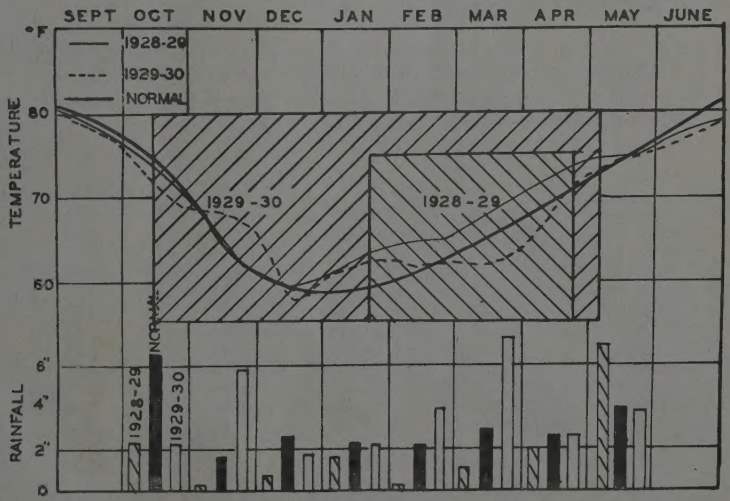

Fig. 1.—Prevailing climatic conditions for duration of insect surveys on celery at Sanford, Fla., 1929-30. The large, superimposed, cross-hatched areas in the center of the chart show the seasons during which the surveys were made, the relative height giving a comparison of the number of collections made each season.

TABLE I.—COMPARISON OF WEATHER DATA FOR THE SANFORD, FLA., DISTRICT, SEASONS OF 1928-29 AND 1929-30.

	A. Entire Survey Period (October to April)			B. Spring Crop Season (January to April)		
	1928–29	Average	1929–30	1928–29	Average	1929–30
Total rainfall (in.)	8.44	20.61	26.25	5.04	9.98	16.49
Departure	−12.17	.....	+6.04	−4.94	.....	+6.51
Av. mean temp. (°F.)	68.9	65.5	67.0	69.4	64.4	65.8
Departure	+3.4	.....	+1.5	+5 0	.....	+1.4

COMPARISON OF INSECT POPULATIONS FOR THE TWO SEASONS

Table II shows the average number of insects caught per 1,000 sweeps from January 20 to April 24 for each of the two years. As shown in figure 1, the spring collections were continued in 1930 for about two weeks longer, but for the comparison of the two seasons only those collections made within the same dates as limited the 1929 survey were used. For this reason the figures used for the 1930 infestation in table II are not the same as those used later in table III, where the collections for the entire spring period are included.

Not all of the insects which were collected are listed here, the Orthoptera, weevils, and Odonata being omitted because so few were captured in the spring of 1929.

TABLE II.—COMPARISON OF INSECT POPULATIONS PER 1,000 SWEEPS DURING SPRING SEASONS (JANUARY 20 TO APRIL 24) OF 1929 AND 1930.

The first column of figures for each year refers to the relative position based on numbers collected.

	1929		1930		Ratio 1929/1930 (approx.)
Thysanoptera	1	1,360.00	1	1,465.00	1/1
Diptera	4	600.00	2	1,180.00	1/2
Aphids	3	1,182.00	3	360.00	3/1
Red spiders	2	1,311.00	4	345.00	4/1
Leafhoppers	8	17.30	5	101.20	1/6
Hymenoptera	9	15.10	6	95.50	1/6
Garden flea hopper	5	97.00	7	70.30	1/1
Other spiders	7	19.90	8	47.70	1/2
Looper larvae	6	26.60	9	18.90	1/1
Coccinellidae	11	7.07	10	17.15	1/2
Miscellaneous Coleoptera	12	3.64	11	16.75	1/4
Miscellaneous Hemiptera	14	2.48	12	12.35	1/5
Celery leaf tier	10	14.85	13	6.15	2/1
Chrysopidae	13	2.90	14	4.74	1/1
		4,659.84		3,740.74	1.25/1
Number of collections	107		106		

The insects have been arranged in order of abundance as found in 1930. The last column gives a rough approximate ratio

of the numbers for the two seasons. An important economic group, the Noctuidae, except for the celery looper, is not represented in these findings, as the habits of both adults and larvae of the remainder of this family are such that they were not captured by sweeping. Thysanoptera stand at the top of the list and were about equally abundant in the two seasons. Various types of Diptera, which ranked second in 1930, ranked fourth in 1929 and were only half as abundant. Aphids ranked third in both years but were three times as abundant during the first year's survey as during the second. Red spiders were fourth on the list in 1930, but the warm dry spring of 1929 caused them to be four times as abundant as in 1930 and to rank second.

The remaining insects maintained about the same relative order during the two years, though the actual numbers present varied considerably as shown by the ratios. While the Hymenoptera stood ninth and sixth, respectively, in 1929 and 1930 the total number counted was six times as great for the second season as for the first. Leafhoppers, which ranked eighth in 1929 and fifth in 1930, also had a ratio of 1 to 6. Miscellaneous Hemiptera held nearly the same position during the two years but had a ratio of 1 to 5. Miscellaneous Coleoptera, with a ratio of 1 to 4, had about the same rating. Celery leaf tier adults, standing tenth and thirteenth in the lists, were twice as abundant in 1929 as in 1930. The most striking feature of the survey was the similarity of the total number of insects for the two seasons, the ratio of which was 1.25 to 1.

The bad outbreaks of aphids and red spiders in 1929 are indicated in the 3-to-1 and 4-to-1 ratios of these insects. The large number of thrips present each season did not result in any apparent damage to celery. The 2.4-to-1 ratio of celery leaf tier adults marks the serious outbreak of this insect in 1929. The main factor accountable for this was the continued warm weather of 1929 (fig. 1), which allowed a building up of numbers, whereas in 1930 the warm January and February was followed by a March much below normal. This continued mean temperature of about 64°F. in March 1930 prevented the rapid development of the celery leaf tier until after the bulk of the celery had been harvested.

COMPARISON OF INSECT POPULATIONS IN FALL AND SPRING

After the comparison of the insect populations for the spring season of the two years, the question naturally arises as to what a comparison of the insect populations on the fall and spring

crops would reveal. Table III shows the results of the counts made during the two parts of the crop season of 1929-30.

As already explained, the figures for the spring collections are not the same as those used in table II, as it was desired in that case to make the comparison from collections limited to the same period. The Diptera (including all flies, parasitic and non-parasitic) ranked first, with an average of 896 for the entire season, but with an average of 1,155 in the spring. This showed about twice as many flies in the spring as in the fall. The great abundance of Tysanoptera in the spring caused these insects to rate second for the entire season. Red spiders were very much in evidence in the spring, even though they were much less abundant than in 1929. Aphids, ranking third, were most numerous during the fall and winter when over 70 per cent of the total were captured.

TABLE III.—COMPARISON OF INSECT POPULATIONS OF THE SPRING SEASON WITH THOSE OF THE FALL SEASON AND THOSE OF THE ENTIRE CROP SEASON, 1929-30.

	Rank for entire season	Number of insects per 1,000 sweeps for entire season	Number of insects per 1,000 sweeps for fall season	Number of insects per 1,000 sweeps for spring season	Ratio Fall / Spring (approx.)
Diptera	1	896.00	615.0	1,155.00	1/2
Thysanoptera	2	855.00	27.0	1,600.00	1/60
Aphids	3	525.00	767.0	302.00	2/1
Red spiders	4	209.00	42.8	360.00	1/8
Leafhoppers	5	173.00	248.0	104.50	2/1
Hymenoptera	6	77.00	54.9	99.90	1/2
Garden flea hopper	7	50.60	23.3	85.50	1/3
Other spiders	8	38.00	24.4	50.50	1/2
Looper larvae	9	16.45	4.8	27.20	1/5
Miscellaneous Hemiptera	10	12.90	15.9	10.10	1/1
Coccinellidae	11	8.95	2.4	14.85	1/6
Miscellaneous Coleoptera	12	6.65	2.8	10.20	1/4
Chrysopidae	13	6.30	6.4	6.22	1/1
Chrysomelidae	14	5.83	6.5	5.20	1/1
Celery leaf tier	15	4.20	.5	7.60	1/15
Miscellaneous moths	16	3.86	3.3	4.40	1/1
Orthoptera	17	1.73	2.6	.91	3/1
Weevils	18	1.54	.7	2.27	1/3
Odonata	19	1.46	.9	1.96	1/2
		2,893.47	1,849.2	3,848.31	1/2.1
Number of collections		253	121	132	

Of the 19 groups of insects tabulated, 13 were more abundant in the spring. Outstanding among these are the Thysanoptera, with 60 times as many in spring as fall; red spiders, with 8 times as many; loopers, with 5 times as many; coccinellid beetles, with 6 times as many; and the celery leaf tier, with 15 times as many.

SEASONAL OCCURRENCE OF ECONOMIC FORMS

This method of regular collections makes possible a rather accurate graphic presentation of the numbers of insects present during each season. In figures 2, 3 and 4 is shown a comparison of the seasonal abundance of the more important economic groups. The upper half of each chart shows the seasonal variation during the spring of 1929, and the lower half presents the results found during the entire season of 1929-30. The charts have been drawn semilogarithmically to give greater emphasis to those insect groups having only a small number present. The points for the graphs, with the exception of the celery leaf tier in figure 4, are the averages for each half month, including all plots under survey at that time irrespective of the size of the celery.

Figure 2 shows the waves of aphids which occurred during the crop seasons, with their biologically related predators and parasites. Not all of the captured Hymenoptera were parasites of aphids but a large majority were. The lag in development of the parasites and predators during the cool weather of November and December of 1929 was so great that insecticidal control measures were used by practically all growers. However, in the spring the aphid outbreak was abruptly terminated in late April by natural control. No records have been kept of the syrphids, as the adults usually eluded the net, and the larvae were not readily swept from the plants.

The more numerous forms of sucking insects, including Thysanoptera (thrips), have been grouped in figure 3. In 1930 the Thysanoptera did not start building up until late in January but they were present in great numbers during April. Leafhoppers were very abundant during the fall of 1929, apparently coming into the celery from the adjacent grass lands and ditch banks and, while they increased somewhat in number during the spring, their presence was much less noticeable than in the fall.

The adults and nymphs of the garden flea hopper *(Halticus*

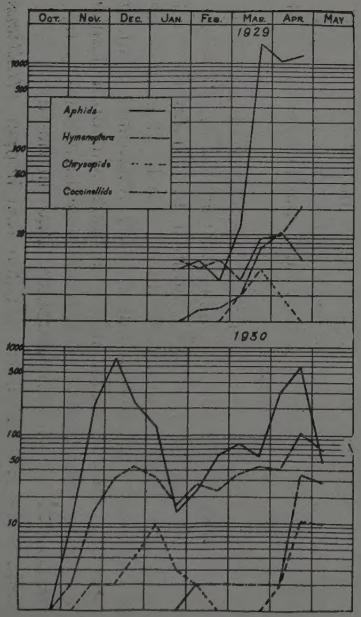

Fig. 2.—Seasonal occurrence of aphids on celery, with parasites and predators.

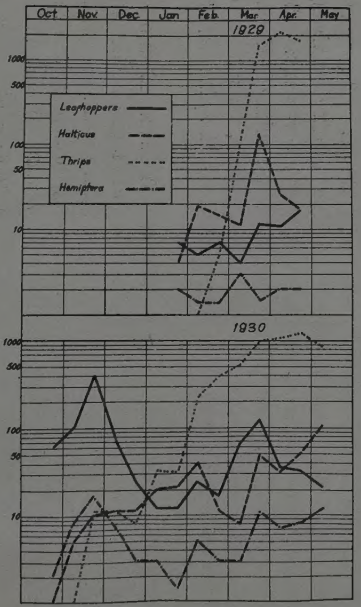

Fig. 3.—Seasonal occurrence on celery of insects of the sucking type (aphids excepted).

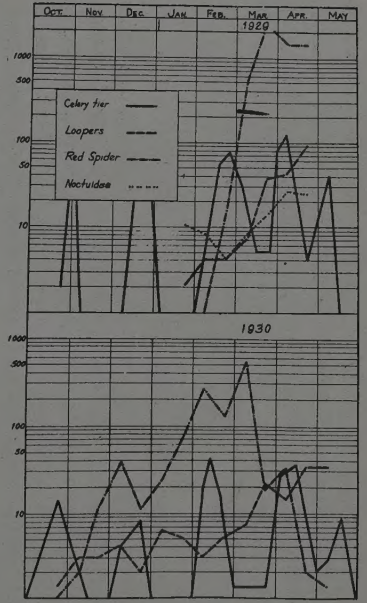

Fig. 4.—Seasonal occurrence of the most injurious insects on celery.

citri Ashm.) were quite abundant on nearly mature celery in the spring of 1929, causing some very pronounced damage. A heavy infestation was carried over to the celery seed beds in late summer and fall. However, when the plants were set in the field the rate of increase was not continued, and no damage was noticed in 1930. The various other Hemiptera noted during the seasons have been tabulated under that general term. These rarely became sufficiently abundant to be noticed.

Figure 4 shows the insects which are normally the most injurious and which attract the attention of the growers. The celery leaf tier (*Phlyctaenia rubigalis* Guen.) is always a potential pest of great economic importance and did much damage in 1929. Since more reliable and extensive data concerning the abundance of celery leaf tier adults were available as the result of other investigations these were used in this graph instead of the survey records. Three definite broods of the moths were noted from February to May of both seasons, but the greater number present in 1929, and the piling up of broods, resulted in serious injury that year. Conditions appeared to be even more favorable for the insect in 1930. Though the February brood of adults was smaller than in 1929 it was earlier, and great damage could have resulted if the following cold weather had not prevented larval development until harvesting was completed.

Red spiders are somewhat of a menace during the winter, as this is usually the season of minimum rainfall. The warm, dry season of 1928-29 allowed them to build up to destructive numbers despite vigorous control measures. Likewise, in 1929-30 they were building up vigorously until halted by the heavy rains of March.

The celery looper (*Autographa falcifera* Kby.) and the cabbage looper (*Autographa brassicae* Riley) are present throughout the season, gradually building up to rather serious numbers by late spring. Whenever they become very abundant disease and parasites become such a very evident limiting factor that the growers pay little attention to them.

Very incomplete records of the Noctuidae were secured by sweepings. During the spring of 1929 bait pans were used to supplement the sweepings, and the record of Noctuidae secured therein has been included. No effort was made to record these insects during the second season.

SUMMARY AND CONCLUSIONS

One of the most obvious conclusions that can be drawn from these studies is the fact that the insects most abundant in the celery fields are not those most destructive there. Thysanoptera and Diptera, which together comprise more than half of the entire insect population, are of little economic importance. Aphids, ranking third in 1929-30, are not considered as serious a pest as some other insects and usually little money is spent for their control. Red spiders, ranking second in 1928-29 and fourth in 1929-30, are sometimes very troublesome. The celery leaf tier, which has done by far the most commercial damage, ranked only tenth and thirteenth in abundance, and in the year of greatest abundance the adults captured comprised only 0.25 per cent of the entire population collected.

Prediction of outbreaks of destructive celery insects is possible only in a very general way, depending on accurate records of climatic conditions and knowledge of the initial populations. In comparing the two seasons it is apparent that climatic conditions determine the abundance of the various insects. Red spiders, for example, were four times as abundant during the dry season as during the wet. Aphids were also three times as numerous during a dry year as during one of normal rainfall. Aphids thrive best on celery in the cool, dry period of fall when parasites and the fungus *Empusa* sp. are least abundant. Two groups of sucking insects were five or six times as abundant during the rainy season as during the dry season, probably because the foliage was more attractive and rainy weather was not unfavorable for their survival. The celery leaf tier was more abundant during the dry season, but this is due more to the high temperature than to the dry weather.

Keeping in mind the factors just mentioned, the growers should be able to ascertain with some degree of certainty just what insects will require control measures. If the warmth of the season is above the average, the celery leaf tier will probably cause trouble. If the season is dry and warm, red spiders will become abundant. A cool fall is usually followed by destructive aphid outbreaks in December.

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J. R. WATSON.....Editor
E. W. BERGER.....*Associate Editor*
H. E. BRATLEY.....*Business Manager*

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TWO NEW SPECIES OF OEDALEOTHRIPS WITH NOTES ON OTHER SPECIES

By J. R. WATSON

(Continued from Vol. XVII, No. 3, page 50)

Oedaleothrips jacksoni Hood was described (Ent. News XXVI, May, 1925) from a single female taken on a limb of Mountain Mahogany *(Cercocarpus panifolius* Nutt.) in Colo. There seems to be no record of any further captures. The writer has received from Mr. H. B. Wells of the Dept. of Ent., Texas Agric. Exp. Station, six specimens taken by him at Waco, Texas on dry bark on Aug. 14, 1933.

Three of these are males and as the male does not seem to have been described, description follows.

Oedaleothrips jacksoni Hood

Male (apterous).

Length 2 mm. Color black with brown legs, the same as the female. In my specimens, both male and female, the third antennal segment, as well as the first and second, is tinged with brown. Head as in female, antennae 1.5 times as long as head. Fore femora greatly enlarged, width across base greater than that of the base of the head, strongly arched, apex on the inside bright yellow. Tarsal tooth long and stout (tho not nearly as long as in *O. hubbelli* Watson) slightly recurved at apex. Abdomen much smaller, especially shorter. Otherwise as in female.

Measurements: Total body length 2.04 mm. Head, length .44 mm., width .30 mm.; prothorax, length .23 mm., width .36 mm.; pterothorax, width .30 mm.; abdomen, greatest width .60 mm.; tube, length .16 mm., width at base .106 mm., at apex .475 mm. Antennal segments, length (width). I, 48 (44); II, 70 (38); III, 163, varies greatly, from 154 to 172 (41); IV, 110 (41); V, 101 (36); VI, 82 (33); VII, 59 (27); VIII, 47 (20).

Nymph. Body length 1.19 mm. Head, including antennae, legs, and last two abdominal segments dark brown, thorax and remainder of abdomen colored bright red by hypodermal pigment between ivory colored spots which cover nearly half of the abdomen. These spots cover the posterior angles of the prothorax, the sides of both mesothorax and metathorax. There are also large blotches in the median line of the meso- and metathorax. Abdominal segments 1 and 2 are free of spots but 3 bears four large ones and 6 to 9 bear a dorsal row. Segments 4 to 6 bear 4 longitudinal white bands, more clear and transparent than the ivory colored spots. Head a little longer than wide. Antennae 7-segmented. Apex of segment 2 with a light spot.

O. hubbelli Watson is closely related to *jacksoni*. The third antennal segment is usually brown but in one male it is yellow as in *jacksoni*. Better characters to separate them are the shape of the head, eyes, and tarsal tooth and the comparative lengths of the head and prothorax. The following key will seem to separate these species.

Oedaleothrips (Hood)

a. Tube yellow. —Texas. *hookeri* Hood.

aa. Tube black.

b. Head much longer than wide, sharply narrowed posteriorly, wider than pterothorax, white blotches on abdomen; at most only antennal segments 1-3 yellow.

c. Antennal segments 1 and 2 yellow; head about 1.5 times as long as broad.

d. Abdominal segment 1 brownish yellow, large ivory colored blotches on segments 2, 4, and 5; antennal segment 1 considerably longer than wide, 3 dark brown. —Fla. *querci* Watson.

dd. At least part of abdominal segment 1 white, antennal segment 3 yellow or light brown.

e. Head widest behind the eyes, prothorax less than half as long as head; tarsal tooth directed forward, eyes prolonged on ventral side. —Col., Texas. *jacksoni* Hood.

ee. Head widest across the eyes, prothorax more than half as long as head; tarsal tooth recurved, eyes not prolonged on ventral side. —Okla. *hubbelli* Watson.

cc. Antennal segments 1 and 2 mostly blackish brown, much darker than 3; head nearly twice as long as wide. —Argentina. *walteri* n. sp.

bb. Head about as wide as long, narrower than pterothorax; no white blotches on abdomen; at least antennal segments 2-4 yellowish. —Iowa. *andrei* n. sp.

MINUTES OF THE FLORIDA ENTOMOLOGICAL SOCIETY
January 13, 1933

President Tissot called the meeting to order at 4:10 P.M. in Room 305, Agriculture Building.

The following members were present: Mr. Calhoun, Mr. Rowell, Mr. Kea, Professor Watson, Professor Byers, Professor Dickey, Dr. Tissot, Mr. Bratley, and Professor Creighton. There were also several visitors in the audience.

Dr. Tissot introduced Professor Watson as the speaker for the day. Professor Watson delivered an extremely interesting paper on Thysanoptera distribution. He named many of the outstanding thrips and gave their regional distribution. He also gave several factors that might possibly limit the spreading of some species. The speaker also gave some points concerning the structure and the life history and habits of the Thrips in general.

After the presentation of this address, the members of the society were permitted to ask the speaker questions concerning the Order Thysanoptera.

The president announced that the secretary had obtained Dr. Mark F. Boyd, Anophelene Mosquito expert, for an address before the society at 4 P.M. Friday, February 10. The meeting to be held in the large lecture room on the first floor of the Agriculture Building.

An announcement was then made by Mr. Bratley, the Business Manager.

This being the regular meeting for the election of officers, the following men were duly elected:

President—Mr. Calhoun
Vice-president—Mr. Merrill
Secretary—Dr. Berger
Business Manager—Mr. Bratley
Editor of The Florida Entomologist—Professor Watson
Assistant-Editor of The Florida Entomologist—Dr. Berger

JOHN T. CREIGHTON.

FOOD HABITS OF TINEOLA UTERELLA*

By J. W. KEA

The moth, *Tineola uterella* Walsingham, which has been present in Florida for a number of years, is apparently becoming more abundant, especially in the southern part of the state. The larva constructs about itself a bag-like covering which is gray in color, about 10 to 12 mm. in length, and with the general shape of a cantaloupe seed. These bags are quite conspicuous when on the walls of a house or other places which they frequent.

All available references state that this insect is strictly harmless, feeding only on the dried remains of insects in spider webs, etc. However, numerous complaints of householders led to a series of observations on their food habits. They refused to eat dried insects when limited solely to them in the laboratory, but upon examining the cases of specimens sent in from various places in the state very minute portions of dried insects were found, thus indicating that this is sometimes an article of their diet. Likewise, they did not eat cotton. However, when offered woolen threads and woolen cloth they ate eagerly. Numerous complaints of their depredations on rugs and other woolen fabrics have been received.

An adult female was reared by the writer in the laboratory of the Department of Entomology, Florida Agricultural Experiment Station, and sent to the U. S. Nat. Museum for identification. The adult is extremely rare and as far as the writer has been able to determine this is the only adult specimen ever taken in Florida.

Although evidence of the attack of a parasite was quite common on many larvae, only one specimen, a hymenopterous parasite, was obtained. This has not as yet been determined.

*Contribution from the Department of Entomology, Florida Agricultural Experiment Station.

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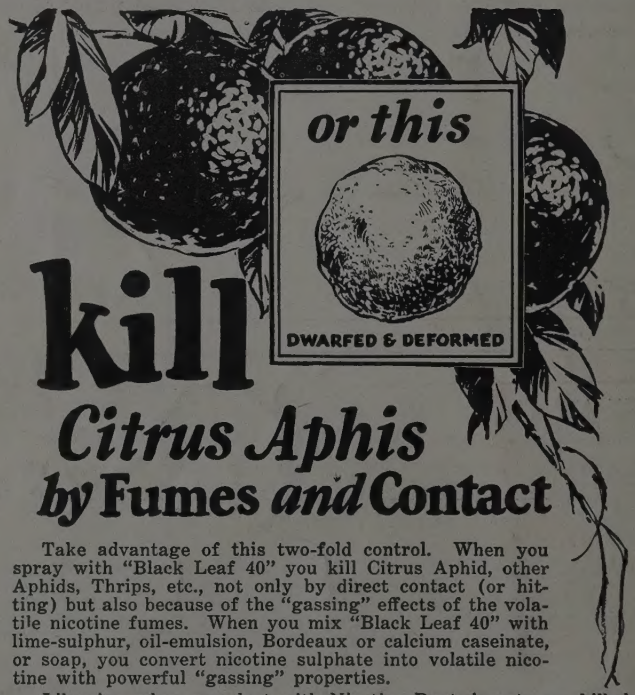

kill Citrus Aphis by Fumes and Contact

Take advantage of this two-fold control. When you spray with "Black Leaf 40" you kill Citrus Aphid, other Aphids, Thrips, etc., not only by direct contact (or hitting) but also because of the "gassing" effects of the volatile nicotine fumes. When you mix "Black Leaf 40" with lime-sulphur, oil-emulsion, Bordeaux or calcium caseinate, or soap, you convert nicotine sulphate into volatile nicotine with powerful "gassing" properties.

Likewise, when you dust with Nicotine Dust, insects are killed by actual contact of the dust with their bodies and also by the powerful nicotine gas.

"ASK YOUR EXPERIMENT STATION"

TOBACCO BY-PRODUCTS & CHEMICAL CORP.

LOUISVILLE, KENTUCKY
(Incorporated)

Kills Aphis

"Black Leaf 40"
40% Nicotine